

Years of Life Lost Due to Deaths in Poland Measured with Potential Years of Life Lost (PYLL) and Period Expected Years of Life Lost (PEYLL) Indicators in Years 2000–2014

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Abstract

Use of PYLL and PEYLL to present mortality figures allows for qualitative assessment of the burden on society caused by different causes of death. The figures from Poland, for a 15 year period (2000–2014), show that the number of PYLL (when the cut-off age is 75 years), decreased by 20%, while both the population and the overall number of deaths increased slightly (by 0.59% and 1.94% respectively). At the same time, the number of PEYLL rose marginally (by 0.24%), which resulted from the formulary nature of the measure. Mortality measured by PYLL reveals that the leading causes of premature death among males are diseases of the circulatory system, neoplasms and external causes (mainly accidents), while in females the leading cause of premature death is neoplasms and the second leading cause are diseases of the circulatory system. When calculating PEYLL, the leading causes of premature death in both sexes is due to circulatory diseases.

Key words: Potential Years of Life Lost (PYLL), Period Expected Years of Life Lost (PEYLL), burden of disease, categories of causes of death, Poland

Słowa kluczowe: utracone lata życia z potencjalnego limitu życia (PYLL), utracone lata życia z oczekiwanego dalszego trwania życia (PEYLL), obciążenie chorobą, kategorie przyczyn zgonów, Polska



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Introduction

One of the fundamental questions in health policy and public health concerns establishing health priorities: which of the existing health problems should become a policy priority? Scarcity of resources contributes to making such choices. Typically, the answer is sought in epidemiology. The priority is that which affects the largest part of the population. However, such an approach is intuitively flawed as the majority of health problems are commonplace and do not often require any further

research. Ergo, the measurement of health problems has evolved over time, becoming focused on ranking health problems according to a system of common weights. Subsequently, the concept of burden of disease was established [1, 2]. The resulting conclusion is that health problems hamper individuals' lives by reducing different human functions and therefore quality of life. Consequently, the core indicators focus on the duration of time affected by a disease and may: (i) measure duration of life lost due to deaths without considering health related quality of life of persons with the disease such as Poten-

tial Years of Life Lost (PYLL), Period Expected Years of Life Lost (PEYLL), Cohort Expected Years of Life Lost (CEYLL), Standard Expected Years of Life Lost (SEYLL) [1–3]; or (ii) count the duration of life lost due to deaths caused by the disease and reduction of health related quality of life caused by the analyzed sequelae (such as the complex units of measure called Disability-Adjusted Life Years (DALY) and Health-Adjusted Life Expectancy (HALE).

The PYLL indicator was primarily introduced because crude mortality rates could not be relied upon to provide a comprehensive representation of the effects of premature deaths and their impacts on the population. The above mentioned limitations of mortality rates, such as not accounting for the different causes of premature death nor the considerable differences in the weighted value of death relative to age (the death of younger individuals has a larger impact on the indicator level than that of elderly individuals), have led to its decreasing usage [4]. This paper focuses on the recent measurements of PYLL and PEYLL in Poland.

Materials and methods

The number of deaths, due to causes of death by category, are used to estimate the time lost and are presented through two different units of measurement of disease burden: Potential Years of Life Lost (PYLL) and Period of Expected Years of Life Lost (PEYLL). No discounting of the lost stream of life was applied.

Potential Years of Life Lost (PYLL)

PYLL (also termed Years of Potential Life Lost (YPLL)) is an indicator of premature deaths and an estimate of the number of years that an individual would have lived if he or she had not died earlier [3, 5]. The PYLL measurement is based on the premise of a conventional cut-off age which people in a given population “should” ideally live to. Death at an age below the conventional cut-off is considered as premature and partly also preventable. The PYLL indicator therefore necessitates a definition of the potential limit of life. Researchers have suggested a range of different limits from 60 years through 65, 70, 75, an up to 80 years [2, 6, 7]. A suggested limit is typically determined by the intended application of the indicator and the value attributed to older ages [3]. The potential years of life lost is given the following formula:

$$PYLL = \sum_{x=0}^L d_x (L - x)$$

Where:

- d_x is the number of deaths;
- L is the potential limit to life (cut-off year of age);
- x is the age of death.

The expression $(L-x)$ can be thought of as a weight that is attributed to death at each given age. This means that the weight attributed to the death of an individual

at the age of 40 is larger than that of an individual who died at 60. As a result, deaths occurring at older ages are given less value than those at younger ages to a degree that deaths occurring at ages above the cut-off year are assigned no value.

The limit chosen for the purposes of this paper is 75 years old. This limit correlates with the average life expectancy at birth for the population of Poland in 2015, which was approximately 77.4 years old (73.6 years for men and 81.6 years for women) [8], but not chosen to suit any further specific application. To avoid linking the concept of PYLL with productivity, which occurs when a limit is fixed at 60 or 65 years, a significant value has been applied to older years of life.

Period Expected Years of Life Lost (PEYLL)

The PEYLL is a measure that reflects the mortality gap between the current period of life expectancy at a given age and the actual age at the time of death [2].

$$PEYLL = \sum_{x=0}^L d_x e_x$$

Where:

- e_x is the period life expectancy at each age;
- L is the age of the oldest survivors;
- d_x is the number of deaths at age x .

The starting point for calculating the PEYLL is a life table based on age-specific mortality patterns. The table estimates the duration of life expected at each age if the current age-specific mortality patterns are to hold in the future. Deaths at each age can be weighted by the expected years of life lost at each age. This paper references the life tables published by the Central Statistical Office of Poland (GUS) for 2015 [8].

The values of the PYLL and PEYLL indicators have been evaluated based on the individual mortality data obtained from GUS for the period of 2000–2014, which specifically include: the cause of death, age at the time of death, the sex of the individual and the year of death. The overall number of deaths from the data base of individual records for the following years is presented below (**Table I**). The figures for some of the years differ slightly from the aggregated figures officially published by GUS, which however should not influence the results.

The sources of the demographic data are publications by the Central Statistical Office of Poland [9].

In accordance with the above outlined method of calculating PYLL, the number of years of life lost in each individual case is calculated by subtracting the person's age at the time of death from the cut-off age, which has been fixed at 75.

For each individual cause of death, the PEYLL was equal to the life expectancy, according to sex, at the given age and year.

The causes of deaths were organized into major categories according to the International Classification of Diseases (ICD10) (**Table II**) [10].

Table I. Number of deaths by gender and year of death

	M	F	Total
2000	194,318	171,581	365,899
2001	191,139	168,486	359,625
2002	190,777	166,713	357,490
2003	193,642	170,797	364,439
2004	194,540	168,350	362,890
2005	197,154	171,370	368,524
2006	198,788	171,251	370,039
2007	201,387	173,798	375,185
2008	201,910	176,319	378,229
2009	203,509	180,272	383,781
2010	199,751	177,952	377,703
2011	198,292	176,893	375,185
2012	201,748	181,501	383,249
2013	200,408	183,748	384,156
2014	193,928	178,565	372,493

Source: Individual deaths records provided by GUS.

Table II. Death causes categories

ICD10 codes	Category
A00-Z99	All causes
A00-B99	Certain infectious and parasitic diseases
C00-C97	Malignant neoplasms
D50-D89	Blood and blood-forming organ disorders
F00-F99	Mental and behavioural disorders
G00-H95	Diseases of the nervous system, eye and ear
I00-I99	Diseases of the circulatory system
J00-J99	Diseases of the respiratory system
K00-K93	Diseases of the digestive system
L00-L99	Diseases of the skin and subcutaneous tissue
N00-N99	Diseases of the genitourinary system
M00-M99	Diseases of the musculoskeletal system and connective tissue
Q00-Q99	Congenital malformations, deformations and chromosomal abnormalities
P00-P99	Certain conditions originating in the perinatal period
R00-R99	Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified
V01-Y99	External causes of morbidity and mortality

Source: ICD-10 Version: 2016.

Results

In 2014, 2,617,565 potential years of life were recorded as lost (PYLL) due to all combined causes of death, resulting in a rate of 6,803 PYLL per 100,000 population (Table III). In the period from 2000–2014, the cumulative number of PYLL observed after each year, decreased by 671,332, indicating a 20% drop from the total in 2000

(Chart 1). The decrease in the PYLL was noted each year, with the exception of a period of slight increase in the PYLL from 2004–2007. Over the years of evaluation, the decrease in the number of PYLL coincided with a slight increase in the population (0.59% total from 2000) and with an increase in the number of deaths (by 1.8% compared to 2000). However in certain years, there were changes in the rate and direction of the PYLL trajectory (Chart 2)

Table III. PYLL and PEYLL per 100,000 population in years 2000–2014

	PYLL			PEYLL		
	M	F	Total	M	F	T
2000	12,345.47	5,073.77	8,597.53	15,939.25	10,817.63	13,299.50
2001	11,982.76	4,882.35	8,321.91	15,829.57	10,656.16	13,162.25
2002	11,849.50	4,732.53	8,178.82	15,799.36	10,616.91	13,126.44
2003	11,646.66	4,650.39	8,036.98	15,626.56	10,654.88	13,061.46
2004	11,863.85	4,613.39	8,121.49	16,022.27	10,686.58	13,268.23
2005	11,961.05	4,629.74	8,175.37	16,291.25	10,884.34	13,499.28
2006	12,039.80	4,619.25	8,205.74	16,487.07	10,968.86	13,635.92
2007	12,094.80	4,620.45	8,230.88	16,650.24	11,078.69	13,769.99
2008	11,935.88	4,570.66	8,127.16	16,653.92	11,165.93	13,815.95
2009	11,634.82	4,557.19	7,974.56	16,459.63	11,244.48	13,762.57
2010	11,085.58	4,259.42	7,564.11	16,124.50	10,992.37	13,476.94
2011	10,906.53	4,214.38	7,453.72	16,127.20	11,058.07	13,511.79
2012	10,788.11	4,200.64	7,388.84	16,196.66	11,211.66	13,624.30
2013	10,363.87	4,111.07	7,137.04	15,933.98	11,217.41	13,499.94
2014	9,797.91	3,994.27	6,802.65	15,569.39	11,081.98	13,253.44

Source: Authors' own calculation based on GUS.

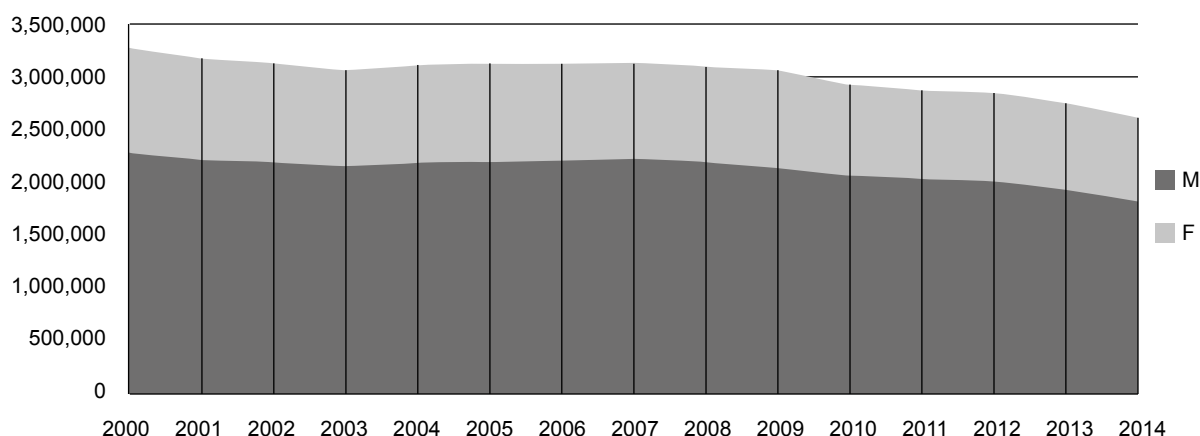
(Table IV). As a result number of PYLLs per 100,000 population was decreasing even faster.

When comparing the PYLL between sexes, the figures are decidedly less favourable among men. In the total years of life lost in 2014, close to 70% corresponded to the deaths of men. The decrease in PYLL occurred in both sexes and presented a similar pattern; in both cases the decrease during the period of 2000–2014 was about 20% (Chart 1).

The nature of the period of expected years of life lost indicator (PEYLL) differs from the PYLL and as such, so does its pattern during the period of study. In 2014, the number of PEYLL was 5,099,736 meaning a ratio of 13,253 PEYLL per 100,000 members of the population

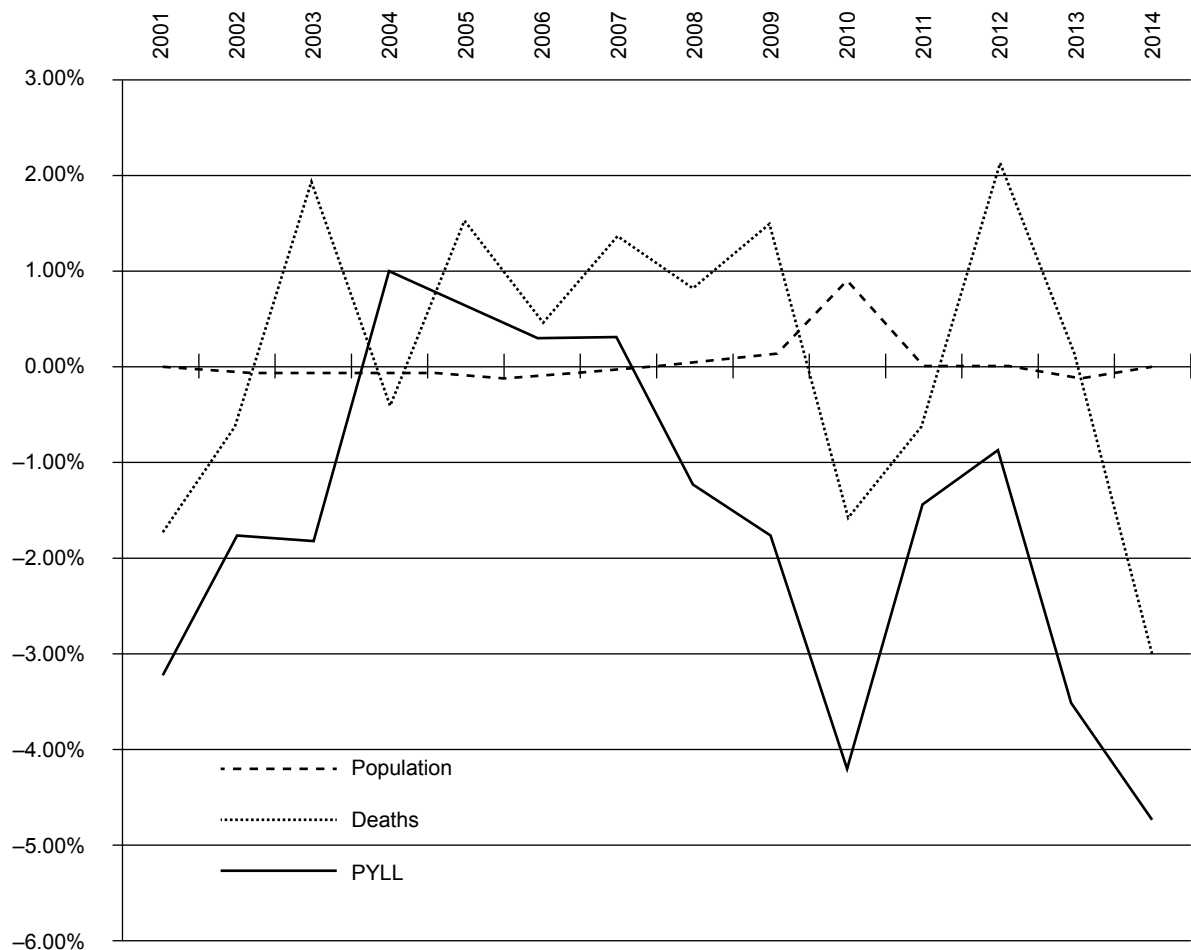
(Table III). From 2000 to 2014, the number of PEYLL grew by 12,152 which accounted for 0.24% of overall number of PEYLL in 2000. The years of life lost among the men according to the PEYLL accounted for 57% of the life lost of the overall population of Poland in 2014 (Chart 3). Over the years number of PYELLs per 100,000 population was generally stable.

In addition to analyzing the rate of change in the numbers of PYLL and PEYLL, it is valuable to note the percentage rates of different individual health problems and their evolution over time. In 2014, 29% of the total years of life lost according to PYLL were due to neoplasms. Diseases of the circulatory system and external causes of morbidity and mortality also accounted for

Chart 1. Evolution of PYLLs from all causes, from 2000 to 2014, population of Poland, by sex

Source: Authors' own calculation based on GUS.

Chart 2. Year to year changes in population, number of deaths and PYLL



Source: Authors' own calculation based on GUS.

Table IV. Change in count of population, deaths and PYLL in Poland between 2000–2014

	Population	Deaths	PYLL
Change	Y/Y	Y/Y	Y/Y
2001	–0.03%	–1.71%	–3.24%
2002	–0.06%	–0.59%	–1.78%
2003	–0.07%	1.94%	–1.81%
2004	–0.04%	–0.43%	1.01%
2005	–0.04%	1.55%	0.62%
2006	–0.08%	0.41%	0.29%
2007	0.03%	1.39%	0.28%
2008	0.05%	0.81%	–1.21%
2009	0.08%	1.47%	–1.80%
2010	0.95%	–1.58%	–4.25%
2011	0.02%	–0.67%	–1.44%
2012	–0.01%	2.15%	–0.88%
2013	–0.10%	0.24%	–3.50%
2014	–0.04%	–3.04%	–4.73%

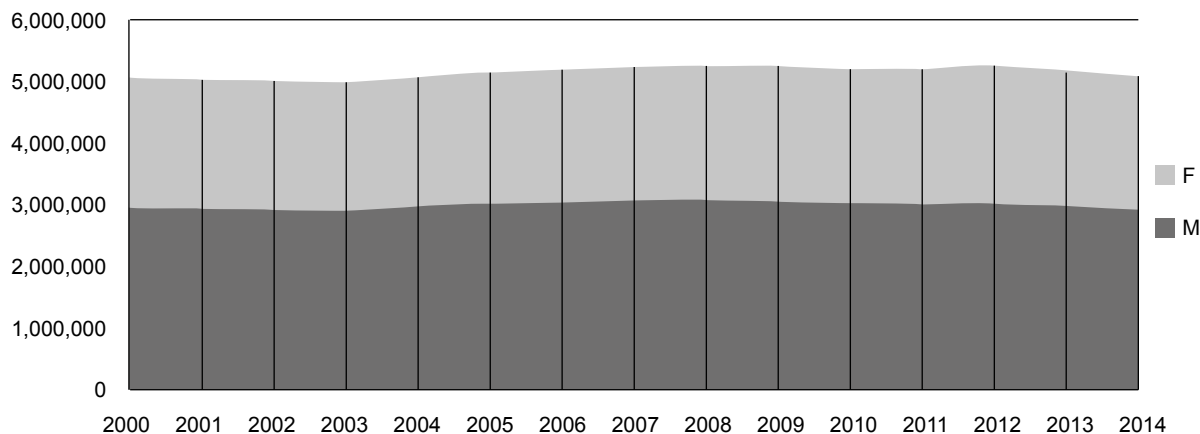
Source: Authors' own calculation based on GUS.

large percentages of the overall number of PYLL (25% and 18% respectively). Between 2000 and 2014, it was noted that across the general population, the proportion of loss of years of life due to neoplasms in total number of PYLL increased (by about 4 percentage points) whereas the share of losses due to diseases of the circulatory system and external causes of mortality groups of causes decreased slightly (**Chart 4**).

There is a considerable difference in the rate of impact of causes of death among men and women. In 2014, the leading cause of PYLL in women was neoplasms (41%) whereas in men the leading causes were diseases of the circulatory system (26%). External causes of morbidity and mortality in the overall number among men were as high as 21% but figured at only about 9% among women.

Since 2000, share of PYLL due to neoplasms in total number of PYLL in women increased significantly, from 34% to 41%, whereas PYLL due to diseases of the circulatory system and external causes dropped from 24% to 21% and from 12% to 9% of the total number, respectively. In men, decreases were observed in PYLL due to diseases of circulatory system from 27% to 26% as well as in external causes of morbidity and mortality from 24% to 21%. However, neoplasms as a cause of death among men in-

Chart 3. Evolution of PEYLLs from all causes, from 2000 to 2014, population of Poland, by sex

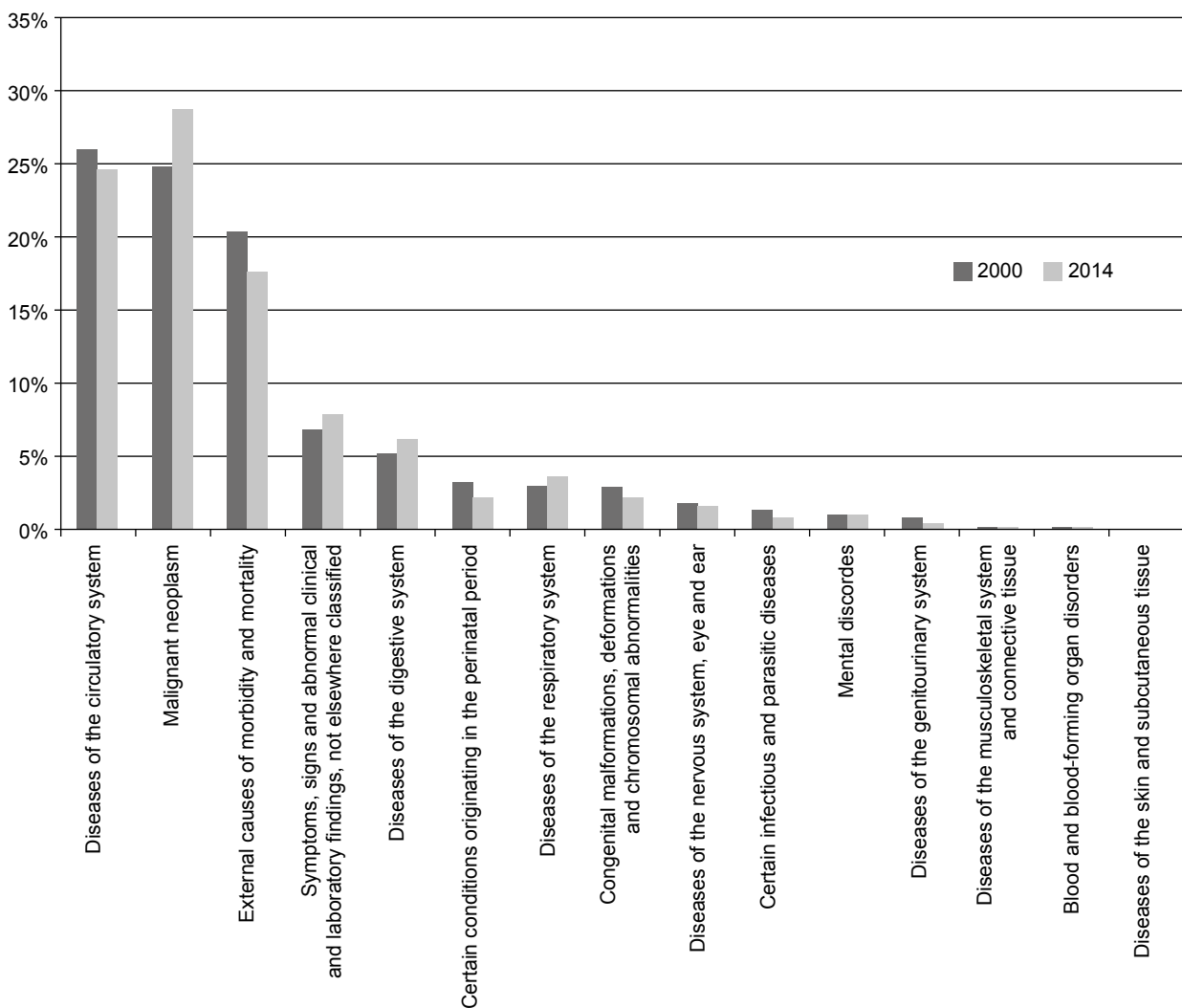


Source: Authors’ own calculation based on GUS.

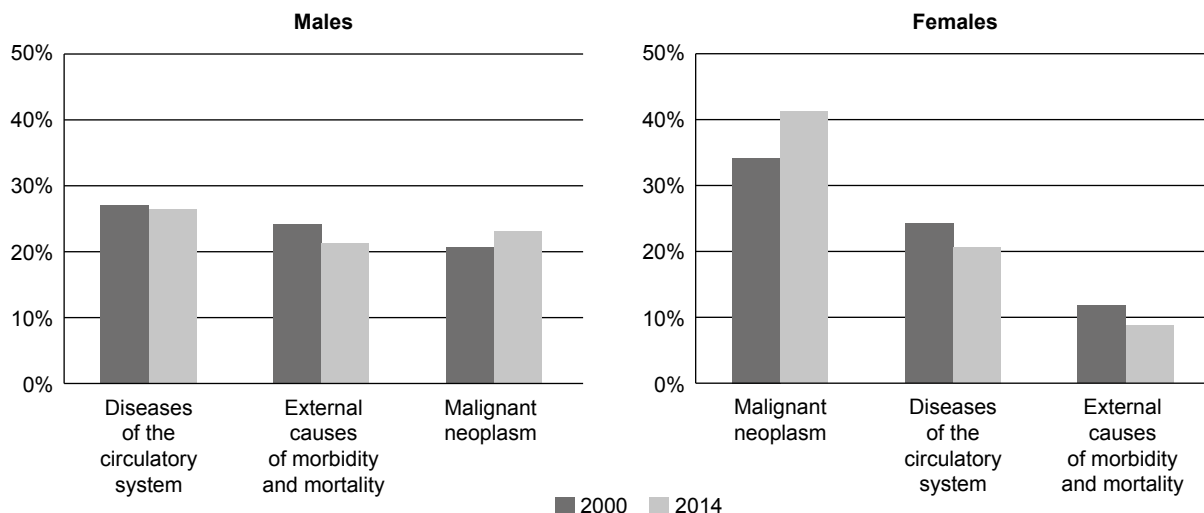
creased significantly, accounting for 23% of the potential years of life lost as compared to the 21% figure noted at the beginning of the millennium (**Chart 5**).

According to the PEYLL indicator, the leading cause of years of life lost in 2014 were diseases of the circulatory system, which fluctuated at around 35% both in 2000

Chart 4. Main categories of causes of PYLL, general population, years 2000 and 2014



Source: Authors’ own calculation based on GUS.

Chart 5. Main categories of causes of PYLL, males and females, years 2000 and 2014

Source: Authors' own calculation based on GUS.

and 2014. In 2014, the impact of malignant neoplasms as a cause of years of life lost according to the PEYLL was at 29% which displayed an increase in the share of total PEYLL compared to the 25% figure at the beginning of the millennium (**Chart 6**). Years of life lost due to external causes dropped from 14% to 11%. Similarly to the PYLL results, the causes of losses of PEYLL in women and men differed. However conversely to PYLL, circulatory system diseases were the prominent cause of loss of expected years of life in both women and men (M – 32%, W – 37%), with neoplasms as the second largest cause (29%: M – 26%, W – 33%). External causes of morbidity and mortality figured at 15% PEYLL in men and 5% in women (**Chart 7**).

Discussion

The method of calculating PYLL is based on an arbitrarily fixed cut-off age, from which the years of life lost are subtracted. For the purposes of this study, the cut-off age has been fixed at 75 years. This figure is the value between current life expectancy in men (about 73.6 years) and women (81.6 years). As a result of this cut-off age, the number of years of life lost according to the PYLL was significantly larger in men than in women. Therefore the overall number of PYLL presented an obvious and widespread excess mortality among men.

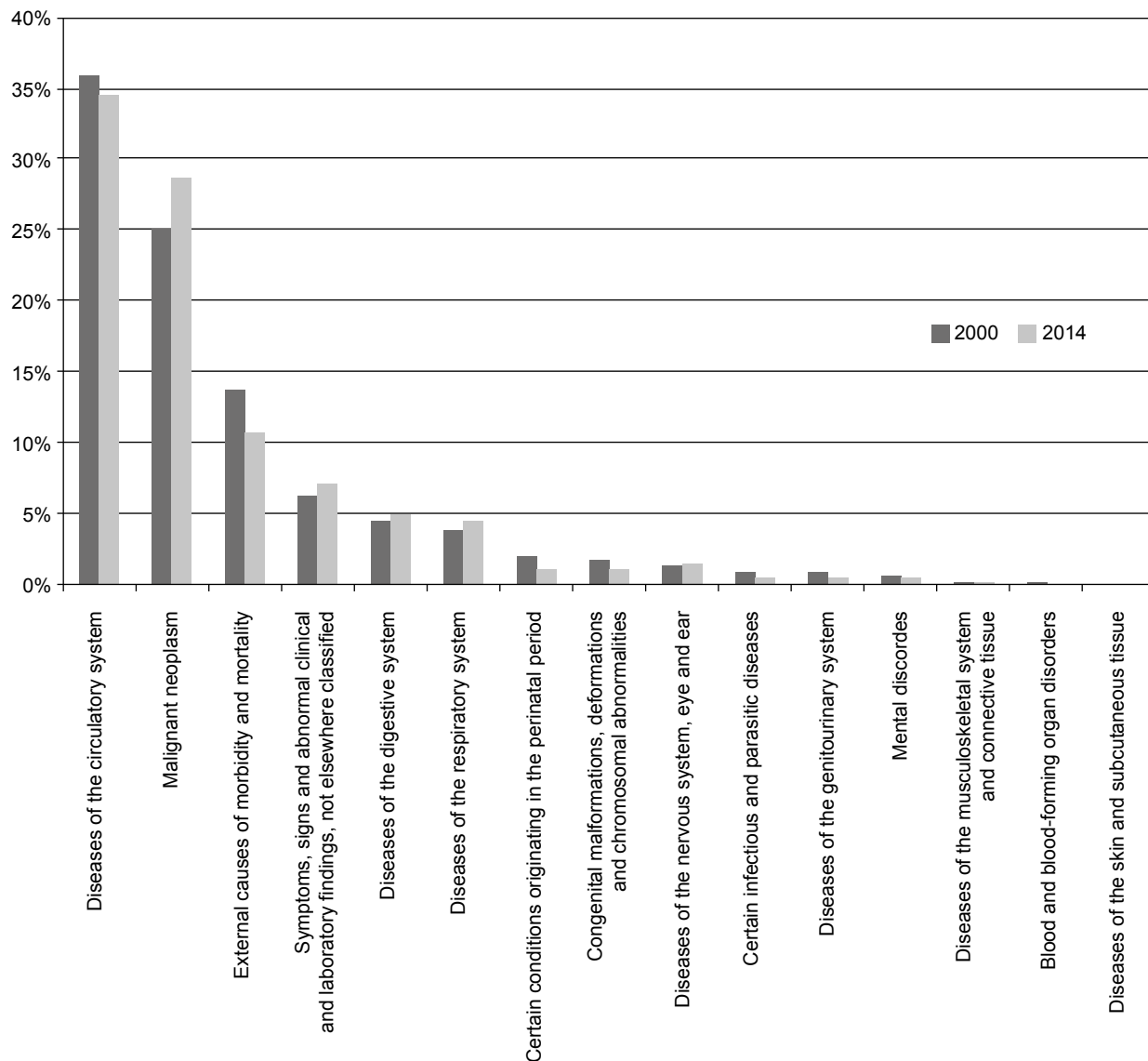
The results of this study present a positive phenomenon; a 20% decrease in the number of years of life lost recorded over the 15 years of analysis. If this trend were to continue over the next decade, the number of PYLL (75) would decrease by about half. The source of this rate of change in premature mortality is uncertain, however it is worth noting that the decrease in PYLL due to diseases of the circulatory system comprise 25%; 32% as a result of external causes; however only 8% as a result of neoplasms. Considerably larger decreases have been recorded in the cases of infectious diseases (51%), disorders of the

genitourinary system (about 59%) and congenital disorders in the perinatal period (about 40–45%), thereby having a substantially smaller impact on the years of life lost.

The pattern of decrease in PYLL among women and men were similar (21% overall), however the PYLL was subject to fluctuate somewhat, relative to individual causes of death. In particular, years of life lost due to neoplasms among men dropped by 11% and by 4% among women. Other sources indicate that the most widespread malignant neoplasms, lung cancer, is becoming less frequent, affects predominantly men, and likely correlates with lower levels of exposure to tobacco. Conversely, the same neoplasms as well as breast cancer, are becoming increasingly common among women [11]. Between 2000 and 2014, a decline in the number of PYLL (75) among women due to circulatory system diseases of 32% was recorded. A similar pattern was observed among men, however the percentage was smaller with an observed decrease of 22% during the period of study. A significant decrease in years of life lost due to external causes of morbidity and mortality has been recorded in both sexes; 30% and 40% in men and women respectively. Further and more detailed research in the future may be beneficial in determining the causes of decreases in the number of PYLL in these two broad categories.

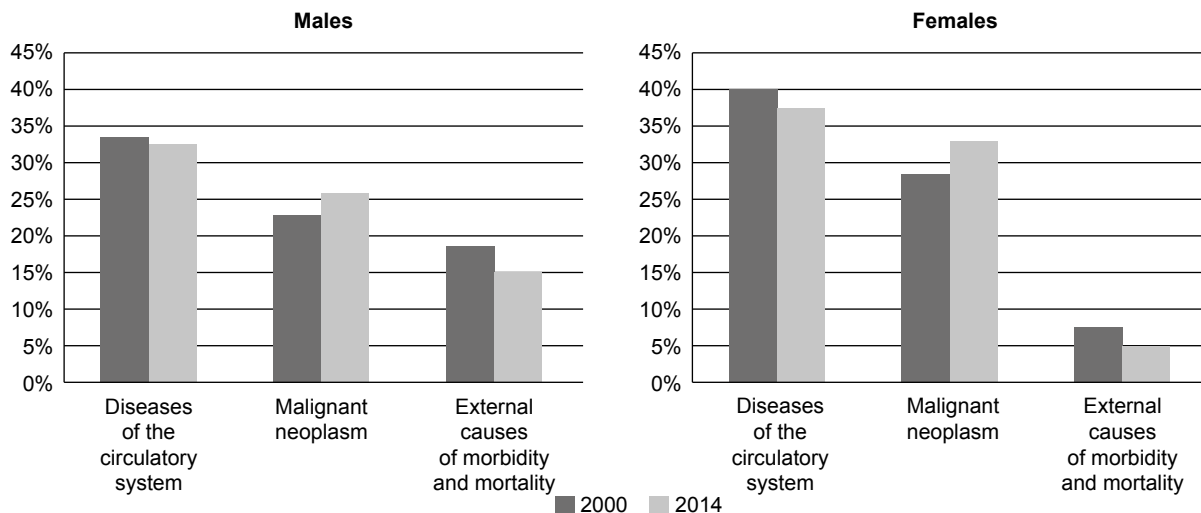
It may also be beneficial to compare the numbers of PYLL between different fixed cut-off ages such as 60, 65 or 70 years. With the lower ages in particular, such a study may provide insight into the country's potential productivity and gross domestic product. Where the cut-off age is 70 or 75 years the analysis treats equally the years of productive age as well as those of the post-productive age. Additionally, deaths occurring prior to the age of 70 are typically considered premature and avoidable. It is therefore highly beneficial to determine the number of years of life that are lost (measured with PYLL and especially with PEYLL) so as to establish and ensure measures for prevention of early death.

Chart 6. Main categories of causes of PEYLL, general population, years 2000 and 2014



Source: Authors' own calculation based on GUS.

Chart 7. Main categories of causes of PEYLL, males and females, years 2000 and 2014



Source: Authors' own calculation based on GUS.

The method of calculating the PEYLL rate takes into account the differences in life expectancy as related to age and sex, which results in smaller disproportion of value of the rates between women and men than observed in the PYLL. The PEYLL indirectly measures the frequency of mortality in younger ages than expected in the given sex and age category. As a result, the data presenting the number of years of life lost due to premature mortality in women and men is more stable (Chart 3). The dynamic of excess mortality among men disappears in the PEYLL because the life expectancy at the age of death is higher in females than males. The higher number of deaths in males compared to females is multiplied by the lower number of years lost which results in a lower conclusive number of years lost in males.

At the same time, PEYLL provides a better image of the scale of premature mortality by age and sex cohorts than PYLL. As a result PEYLL also more clearly indicates that the primary source of premature mortality are diseases of the circulatory system (about 35% in men as well as women). Malignant neoplasms are the second leading cause of death and pose a decidedly larger problem in women than in men (33% and 26% respectively). PYLL does not account for deaths occurring at ages above the fixed cut-off age (75 years). PEYLL counts deaths at all ages and thus presents the real burden of disease on society.

The pattern of the PEYLL rates differs considerably from the PYLL between 2000 and 2014. During these years, the life expectancy in both sexes and at particular age groups increased [12]. As a result of this increase, the number of overall PEYLL did not change (as is predictable based on the nature of the formula), wherein the percentage increased by 3% in women and decreased by 2% in men. In certain categories of causes of mortality, several interesting differences were noted. Resulting numbers of PEYLL due to diseases of the circulatory system showed slight improvement; in both women and men, the number of PEYLL decreased by about 3–4%. Considerably more favourable results can be observed in the figures representing external causes of morbidity and mortality, where their impact on premature mortality decreased among men by 20% and by 29% among women.

The impact of loss of PEYLL from malignant neoplasms shows adverse results through a 12% increase in men and as much as a 20% increase in women. In both cases it is necessary to interpret these figures (relative to the life expectancy in the given study group) as an increase in the number of premature deaths due to neoplasms. Another interpretation of this phenomenon is the gradual disappearance of circulatory system diseases as a cause of death in older individuals with an increasing appearance of neoplasms in their place. It is also worth noting the large increase in premature mortality due to disorders of the respiratory and gastrointestinal systems. A separate issue is the increase in the number of PEYLL due to symptoms and undetermined causes which indicates the flaws in postmortem diagnoses and reporting systems.

Conclusions

The PYLL and PEYLL indicators play an important role in complementing the widely applied mortality measures in public health; such as crude death rates and standardized death rates (CDR, SDR) [13, 14]. The information contained in the PYLL and PEYLL predominantly reflects observations made on the basis of the above mentioned measures [14–16]. However, the PYLL and particularly the PEYLL make it possible to identify the number of years of life lost due to premature deaths by categories of diseases more accurately than when using the CDR or SDR. Such information can and should be used to provide direction for establishing priorities in the scope of public health and healthcare. It is recommended that the analyses presented in this paper be developed further and in greater detail, and include a deeper analysis of the categories of causes of death (e.g. ischemic heart disease) as well as the categories of individuals affected (e.g. residence, marital status, etc.).

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